Feedback Control of a Cylinder Wake Low-Dimensional Model

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In a two-dimensional cylinder wake, self-excited oscillations in the form of periodic shedding of vortices are observed above a critical Reynolds number of around 50. These flow-induced non-linear oscillations lead to some undesirable effects associated with unsteady pressures such as fluid-structure interactions. The only way of suppressing the self-excited flow oscillations is by the incorporation of active closed-loop flow control. In this effort, a control scheme based on a low dimensional, proper orthogonal decomposition (POD) model is developed and the closed-loop wake stability is investigated. The POD model was developed from CFD data of the two dimensional circular cylinder wake at a Reynolds number of 100. The proposed linear feedback controller acts on the estimation of a single POD mode only. A stability analysis of this control law was conducted and conditions for controllability and asymptotic stability were developed. The control approach, applied to a four mode cylinder wake POD model stabilizes the entire wake. While the controller uses only the estimated amplitude of the first mode, all four modes are stabilized. This suggests that the higher order modes are caused by a secondary instability. Thus they are suppressed once the primary instability is controlled.

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